Management of the Internet and Complex Services

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Deliverable 1.1
Initial world wide network and service management research map, new challenges of IT service management

The EMANICS Consortium

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1 Executive Summary

The main objective of EMANICS Network of Excellence (NoE) is to foster the joint European research and teaching activities regarding network and service management topics to increase the degree of collaboration between the partners of EMANICS, and thus strengthen European research.

To initiate a long term vision and integration program of European research activities regarding IT management topics within the NoE, in the first step the identification of the current research fields of the participating EMANICS partners as well as the thematic mapping of research topics and the assignment of experts within the various fields of research was done. Based on the results of a survey, initial EMANICS research and teaching maps have been created. Thoughts are underway how to obtain a world wide research map of network and service management.

In order to evaluate the achieved integration within the EMANICS network an important task is the generation of integration graphs representing the level of collaboration between the members of the network in an appropriate way. Measuring the degree of integration within the network thus requires the identification of suitable metrics, based on quantitative indicators, being able to adequately reflect the integration within the network with respect to joint activities. As during the project the degree of collaboration between the partners as well as the level of integration within the network continuously grows, it is essential to develop a tool which automatically generates and maintains the integration map based on information stored in a repository.

The visibility of EMANICS by other communities will be evaluated by visibility indexes. Reports on this topic will follow.

Another important activity of WP1 is to establish a common vision of promising future research topics and new challenges in the domain of network and service management. The challenges will be identified through discussions in panels and workshops, not only among EMANICS partners, but as well as through interactions with industry, service providers and consulting companies. Such information should serve as an appropriate reference for researchers in order to write project proposals as well as to identify future research involvements.

2 Introduction

Collaboration between European research institutions has been done so far more or less on an ad-hoc basis, mostly based on personal relationships and knowledge. The objective of EMANICS and especially of work package 1 is to provide a basis where research and teaching activities of institutions and researchers can be maintained, fostered, and accessed by everyone. This should enable a systematic collaboration in defining for example larger size research projects, writing joint papers, or identifying topics for joint PhD committees. Such information is relevant also for people who coordinate research and standardization in the area of network and service management.

Discussions have been started to develop a world wide research map of network and service management. The idea was to analyze data held in databases that include information about reviewers for conferences and their topics of interest (*e.g.*, JEMS [2]), and to use this information to generate such a map. So far, such a generation is not possible, because of not suitable organization of the data.

Although an analysis of the available data has already shown that it is not sufficient for the purposes of WP1, a request has been issued to the administrators of JEMS to provide available data in order to have a starting point.

Since the questionnaire [1] that was distributed among EMANICS partners included also questions with respect to teaching activities, an initial map of teaching activities was generated.

A major objective of WP1 is to evaluate:

1. the integration among EMANICS partners as well as the
2. visibility of EMANICS to other communities.

The work as reported in D1.1 concentrated on the development of integration metrics resp. indexes to evaluate the present collaboration among EMANICS partners. An initial integration report of all work packages in terms of the basic indicators is provided on the EMANICS web site. However, extensive work will be done on this topic in the future since there have already been a lot of discussions so far.

In a next reporting period outcomes of the work on visibility indexes, including such aspects as whether a paper was accepted in a journal or conference, will be reported.

Beside the calculation of the integration indexes, updates of the basic integration information needs to be done in a distributed way by each partner. Appropriate mechanisms are necessary to support this. In order to gain experience and to identify requirements, a prototype of such a mechanism is developed by WP1. After reaching a consensus, a request for a productive implementation with precise requirements will be issued to WP4.

D1.1 also reports on challenges of network and service management. It provides an overview of the known and identified challenges so far, and establishes a process to identify future challenges.

2.1 Purpose of the Document

Deliverable 1.1 reports on three issues:

- The initial map of research topics on network and service management among EMANICS partners, as well as proposes steps to derive a map of world wide research in this area. Besides, an initial map of teaching activities among EMANICS partners is derived as well.
- The initial integration graphs among EMANICS partners in order of visualizing the collaboration among partners. A large discussion between partners has already emerged on how to quantify the integration. D1.1 summarizes this discussion and proposes the next steps
- The already identified challenges of network and service management as well as the process how to identify future topics of interest.

2.2 Document Outline

Chapter 3 contains a detailed description of the initial research and integration map among the partners of the EMANICS network. Based on a consolidation of the results of the WP1 questionnaire, in Section 3.1 an initial research map is established and several mechanisms for maintaining and enhancing the map are discussed in Section 3.2. Section 3.3 then addresses the world wide network and service management research map outlining several important aspects, *e.g.*, the generation of a map based on existing data. In Section 3.4 for each particular work package an initial integration graph among the EMANICS members is presented. Additionally, an overlay map reflecting the degree of integration and thus representing a snapshot of current collaboration is depicted. Section 3.5 then addresses various aspects with respect to the refinement and extension of quantitative indicators for integration within the NoE. In Section 3.6 finally an initial teaching map reflecting current and future teaching activities within the EMANICS network is presented.

Chapter 4 addresses new challenges of IT network and service management within various fields of research that have been derived on the basis of several discussions with partners, experts as well as industry, and determines a process how to identify future challenges.

As the EMANICS network provides the opportunity to establish joint Ph.D. committees, Chapter 5 contains a list of joint committees, which have been established so far in the course of the EMANICS project.

Chapter 6 finally contains a conclusion and summarizes fundamental aspects of the work. Bibliographic references in Section 7 and a list of abbreviations in Section 8 complement this work.

3 Initial Research and Integration Map among EMANICS Partners

Although it is only require for the D1.1 to report on research activities, the questionnaire that was developed to acquire research interests among EMANICS partners included also questions about existing collaborations. Therefore, D1.1 reports on the **initial integration map.**

3.1 Initial Research Map among EMANICS partners

In order to initiate a long term vision and integration program of European research activities regarding IT management topics within the Network of Excellence (NoE), an initial step is to identify current and future fields of research of participating EMANICS partners. Since so far, collaboration between research institutions was done more or less on an ad-hoc basis, the objective of this work package is in the first step to develop a repository, respectively a map of research activities of each partner to allow a more systematic approach in establishing collaborations.

Although not every partner is a member of work package 1, our objective was to identify and collect information about research activities of all EMANICS partners. To obtain this information, a **questionnaire was developed and sent to all members of the NoE**. All members provided feedback.

Beside the questions related to the research activities of each partner, the questionnaire included questions related to teaching activities. Based on this information it was also possible to create an **initial map on teaching activities of EMANICS partners** which will serve as the basis for a common course program. WP1 will report on these activities in a next deliverable.

Based on the results of the survey [1], an initial map of network and service management research activities has been developed (Figure 1). This initial map represents a thematic map of research topics within every institution and thus facilitates the foundation of smaller research groups within the NoE in order to work on similar research topics, and additionally serves as a means to identify experts within each research domain.

Figure 1: Initial Network and Service Management Research Map of all EMANICS partners

3.2 Maintaining and Enhancing the Research Map

As the development of the questionnaire and the analysis of the results was the right mechanism to acquire the initial research and integration map among EMANICS partners, a more adequate mechanism is necessary in order to extend and maintain this information. Filling out questionnaires is time-consuming in the phase of writing down and the analysis itself. Furthermore, it reflects only the current situation of research activities of an institution when the questionnaire is being asked to be filled out.

Updates have to be done in a smooth and simple way by all partners involved to omit long delays and inaccurate information. Since researchers may leave institutions, a fast change of the research interests of an institution can easily occur.

It is necessary to think of an **adequate concept to enter, update, and maintain information about research activities and collaborations in a distributed way** where all researchers world wide would fill in data, and requested research relevant information would be generated.

3.2.1 Requirements for a Concept to Acquire and Maintain Information about Research Activities

Requirements can be identified as follows:

- **Specification and formalization of information that is relevant for research collaborations** and is not covered by existing databases
- **Specification of a taxonomy** of network and service management
- **Specification of a process to acquire, update and validate** the relevant information
- **Specification of a concept and a management tool** for acquiring the identified relevant information
- **Visualization of the results** for specific purposes with specific views

3.2.2 Solutions

There already exist databases for assigning experts to review papers according to their field of expertise such as the JEMS database [2]. All databases are, however, using their own classification of topics of expertise. A favorable aim is the creation of a **taxonomy** of network and service management, similar to the one created by ACM on Computer Science [3]. The advantage of having such taxonomy is that authors of research papers can include some well defined keywords, which help the organizers of an event to find appropriate reviewers. Further more, the taxonomy helps to formalize the information that serves as the basis for the research map.

The taxonomy should get implemented within the JEMS system, which is used for most events in this area. Within JEMS individual researchers can express their areas of expertise, based on this taxonomy.

The taxonomy will be published as an additional WP1 deliverable. A small group of EMANICS researchers will take the lead and develop a draft version of such taxonomy. The draft will than be submitted for review to the two main organizations active within the area of network and service management: International Federation for Information Processing (IFIP) WG6.6 [21] and Institute of Electrical and Electronics Engineers, Inc., (IEEE), Committee on Network Operation and Management (CNOM) [22]. The chairs of both groups, as well as the maintainer of the JEMS system, will be invited to participate

in preparation of the draft. The draft should be discussed at the IM'07 conference, which takes place May 21-25 2007 in Munich, Germany, [23].

Although the taxonomy provides the common basis for formalizing research topics, other information necessary for collaboration is relevant as well. Examples are information about labs equipments, existing participation in projects, involvement in project proposal etc.

3.3 Initial World Wide Network and Service Management Research Map

3.3.1 Generating the Map from Existing Databases

In order to develop a world wide network and service management research map, the initial thoughts where devoted to the point of using the JEMS database in order to extract data for such a map. Currently, JEMS does not allow this, and some effort needs to be done in order to get this happen. A request has been issued to the administrators of JEMS to provide the necessary input which, however, takes some time. WP1 will report in the next deliverables on the outcome of the analyzed data and the initial world wide network and service management research map.

3.3.2 Defining a Process to Acquire, Update and Validate of Relevant Information

Far more important than the analysis of the available existing information is to establish a long-term process to acquire, update and validate the information about research and teaching activities. Discussions on the process have already started within WP1, and the outcomes will be published in the next deliverables.

3.4 Initial Integration Map among EMANICS Partners

Another important aspect that is included in the deliverable D1.1 is to establish and maintain an initial integration graph among EMANICS partners in order to evaluate the degree of integration achieved within the network. A research topic itself is a **concept that visualizes and quantifies the integration** in an adequate way, reflecting time scale of collaboration and types (*e.g.*, paper, presentation, prototypes).

There are several approaches to establish such a map. The first approach was to examine the collaboration of partners within the work packages (WP1 to WP9). It has to be noted that the dynamics of network and service management reflects also in the collaborations which are dynamically evolving.

The presented initial integration map represents the current snapshot of collaborations which may vary in time scale from long projects to short visits and papers or presentations as a result of collaborations. This leads to several graphs that reflect the EMANICS members in terms of how connected they are and how many connections between partners currently exist.

Looking at the graphs (Figure 2 to Figure 11) only collaborations as such are depicted. No quantitative conclusions have to be done. Lines are drawn only once, even if partners collaborate in different subtasks. Thus, a line in the integration graph indicates that there exists at least one kind of collaboration between the two institutions, but not how many actually.

An exception is WP2, where all four subtasks are shown in the graph. Showing each subtask separately was not possible for the other WPs, as either no subtasks as such

are defined so far, or their number is too high, which would make the graph too complex. In Figure 12 and Table 1, which give a summary of the before show graphs, WP2 is treated as the others, i.e. even if a partner is involved in more than one subtask, it is counted only once.

We use the term “participation of partners” in a WP, if no subtasks or concrete joint activities are planed, thus showing only a partner’s membership in a working package, and the term “collaboration of partners”, if there are concrete joint activities are planed or already realized.

The following sections contain a short description of the work packages as well as integration graphs indicating the collaboration of the EMANICS partners participating in the particular work package. All graphs of all packages have been visualized for sake of completeness. The graphs are based on data from the WP1 survey and on the deliverables of WP2 and WP8.

The last section contains a kind of “overlay graph” reflecting all the collaborations of all work packages together in one figure and thus the number of lines indicate the connection within the NoE for every institution. In addition, there exists the possibility to integrate quantitative metrics in the graph, as for example for common activities, common research goals as well as common exchange programs. Another important aspect is on the one hand to annotate the links with activities and on the other hand to weight the links between the institutions in the integration graph in order to quantify the degree of collaboration of partners within the NoE. Section 3.5.1 defines a first approach for weighting the links.

3.4.1 Collaboration between Partners that would exist also without EMANICS

As a result of the WP1 questionnaire which was sent to the EMANICS partners, some general collaboration (i.e., collaboration that exists also without EMANICS) between the members of the EMANICS project with other universities or institutions have been identified. Furthermore, as indicated in [4] some more general relationships between the partners within the NoE could be identified. Figure 2 illustrates the collaboration between EMANICS members which already exists, also without the EMANICS project.

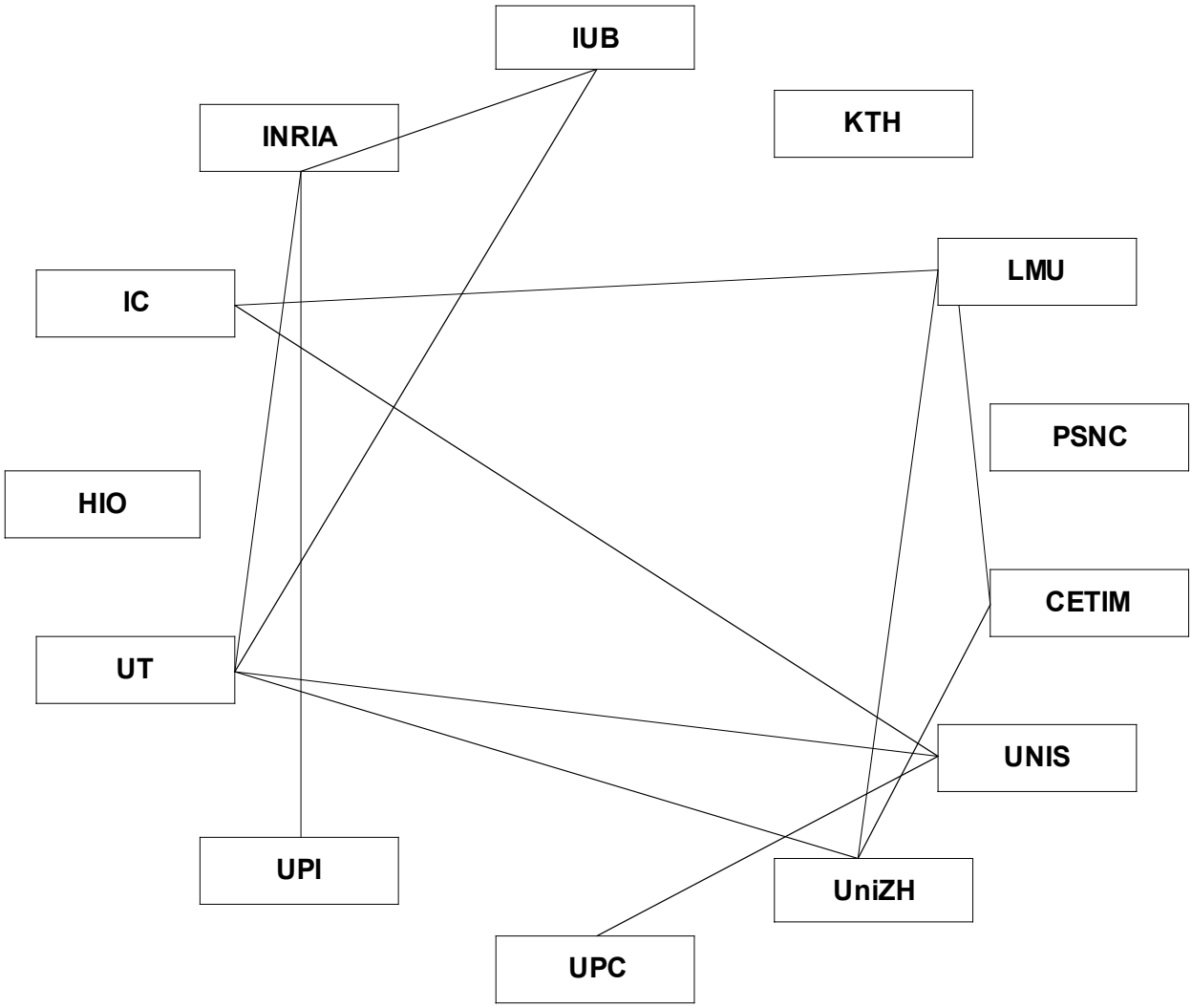

Figure 2: Already existing collaboration between partners

As could be seen, the current integration and collaboration between partners is not very explicit. EMANICS has strengthened the collaboration already to a great extent as visualized in Figure 12.

3.4.2 Participants in Work Package 1

Figure 3 presents an overview of partners participating in work package 1 (EMANICS Vision & Integration Program) of the EMANICS project. Although not all partners are member of WP1 they provided information about their research and teaching activities. The lines indicate the partners participating in WP1.

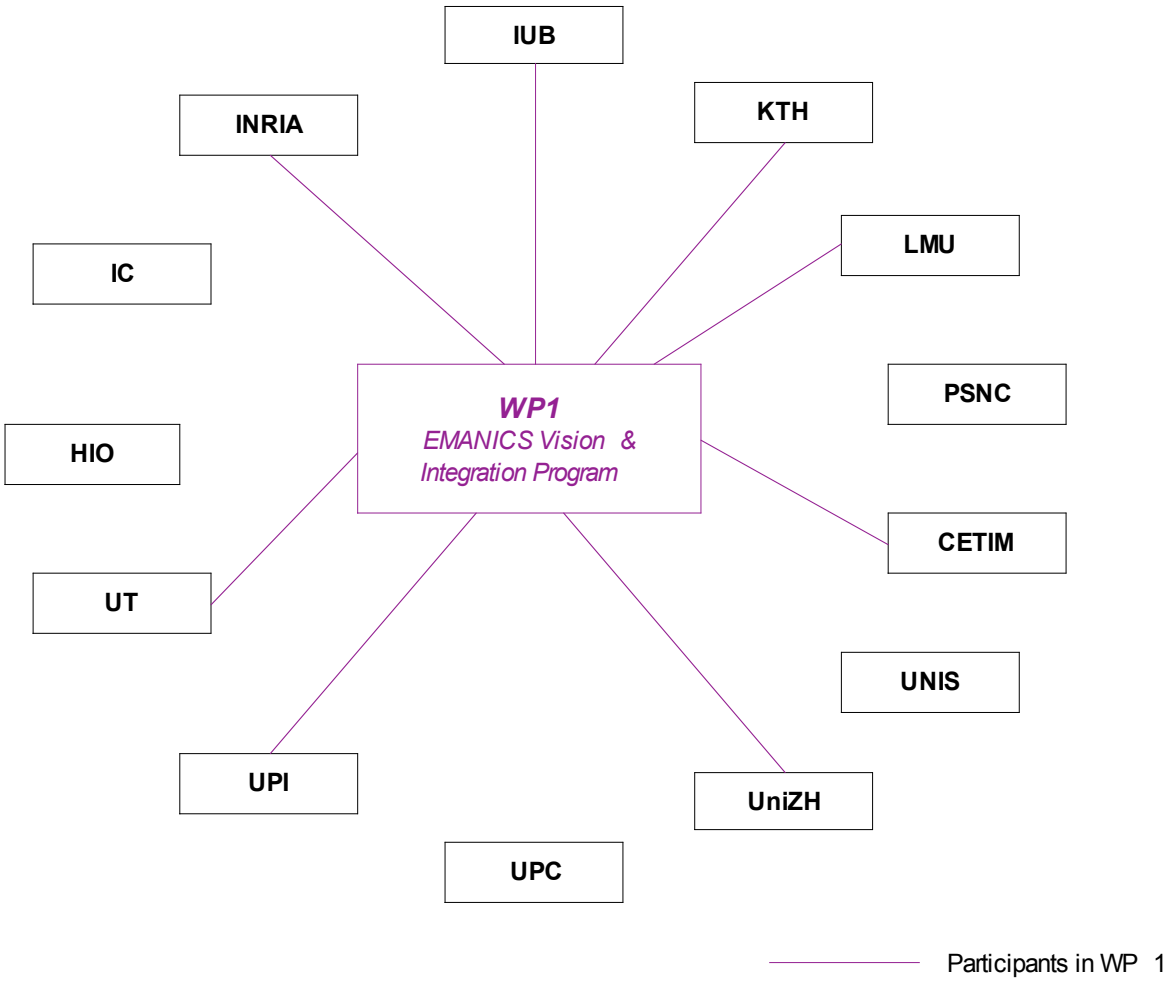

Figure 3: Participants in WP1

3.4.3 Collaborations in Work Package 2

Figure 4 shows the partners as well as existing collaboration in work package 2 (Virtual Labs and Common Test beds). Main research activities within WP2 are to establish access to test beds and virtual test environments, *e.g.*, VoIP test beds and furthermore to provide access to several repositories with measurement data as for example IP traces or SNMP traces. Although some institutions as for example UniZH, UNIS and KTH are formally not involved in WP2 they do participate in the work package and provide some input. Additionally, although the collaboration between the institutions is presented multiple times for each specific subtask (e.g., VoIP and TRACE) within Figure 4 each collaboration between two EMANICS partners is only counted once in Table 1.

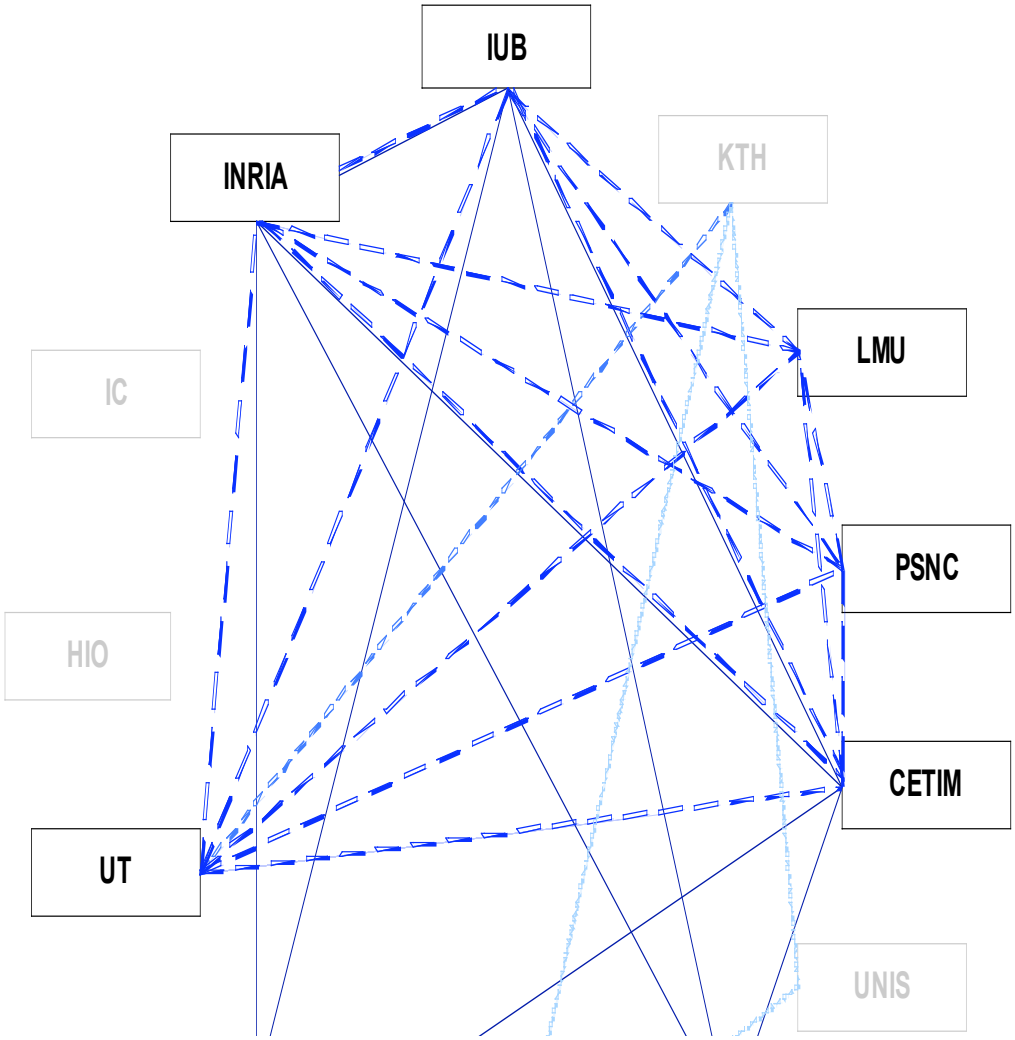

Figure 4: Collaboration in WP2

3.4.4 Participants in Work Package 3

All partners of EMANICS participate in this work package somehow, as organizers, members of the technical program committee, panel chairs etc. The main objective of WP3 is to organize EMANICS conferences as well as several related workshops on specialized topics in which the results of the project will be presented.

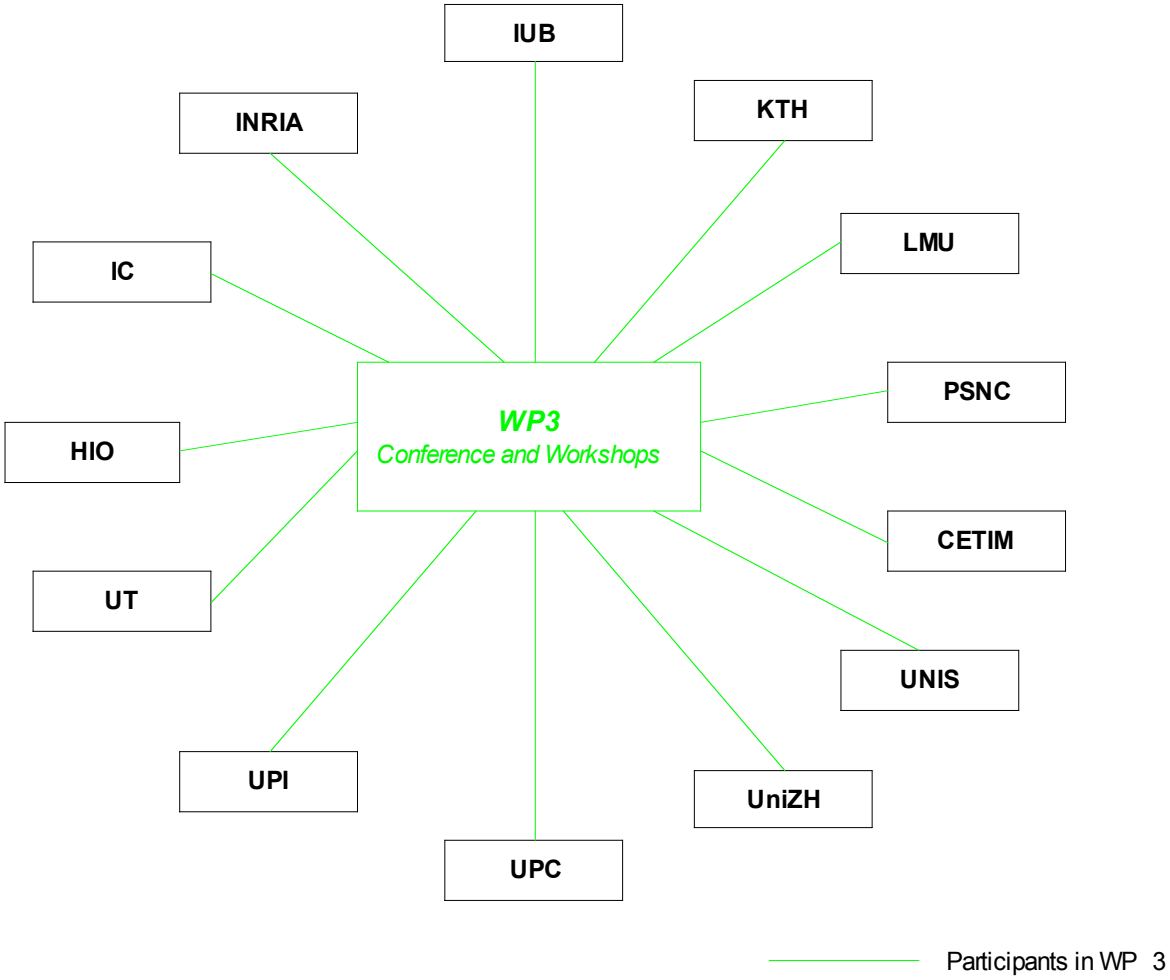

Figure 5: Participants of WP3

3.4.5 Participants in Work Package 4

Figure 6 graphically presents the partners of WP4 (Electronic Dissemination Environment) which has the objective to identify the information as well as the flows of information that is useful for collaboration and to establish the overall infrastructure for electronic collaboration and knowledge dissemination.

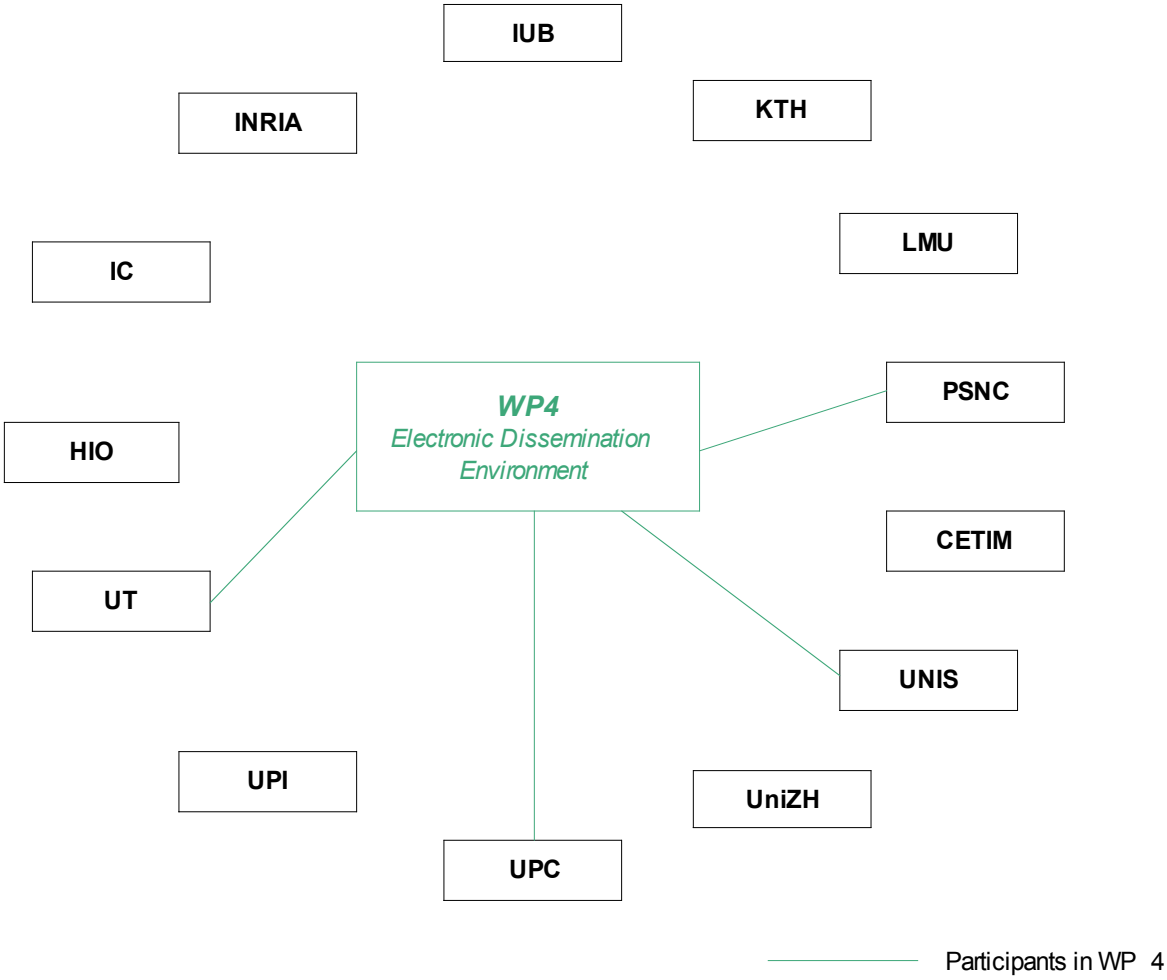

Figure 6: Participants in WP4

3.4.6 Participants in Work Package 5

Figure 7 depicts the members of work package 5 (Training, Standardization and Technology Transfer) of the EMANICS project.

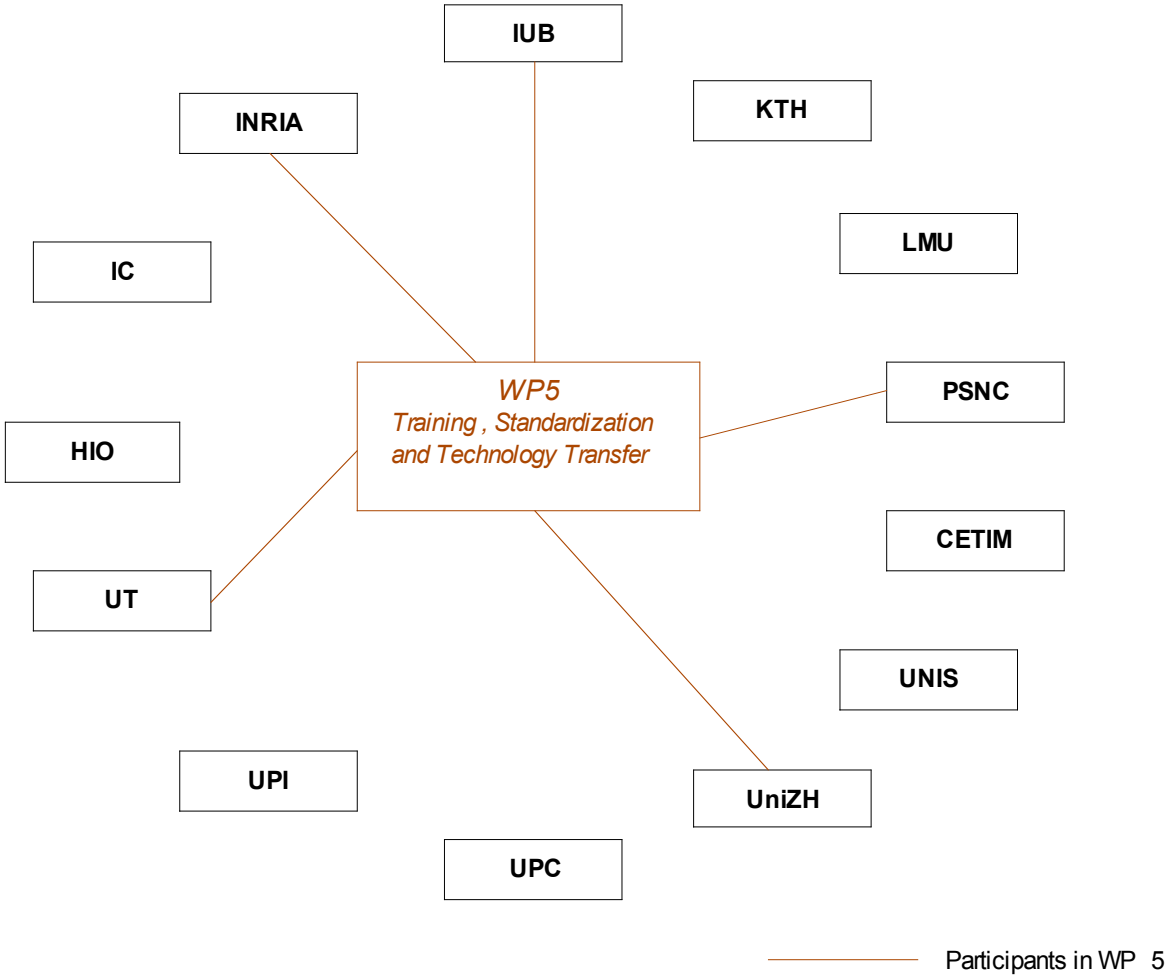

Figure 7: Participants of WP5

3.4.7 Participants in Work Package 6

The major objectives of work package 6 (Open Source Initiatives & Joint Software Development) are on the one hand to establish and maintain a map of open source software in network and service management, and on the other hand to foster the acceptance of NoE-based open source components. As indicated by the lines, currently 6 partners of the EMANICS project participate in WP6.

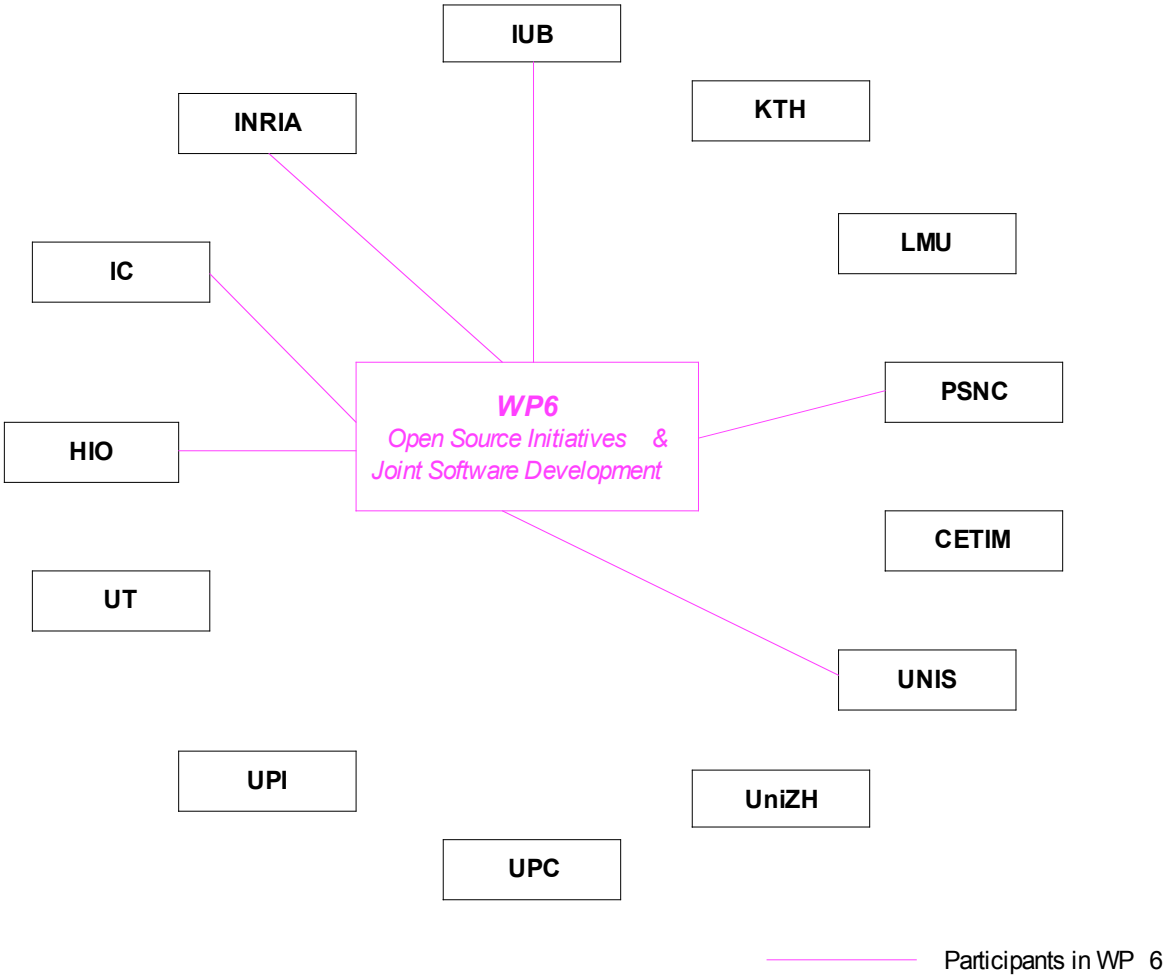

Figure 8: Participants in WP6

3.4.8 Collaborations in Work Package 7

Figure 9 presents the partners of WP7 (Scalable Network Management) as well as existing collaboration between the members of the work package. Major efforts of WP7 are to establish a common vision and to provide uniform guidelines for scalability research in the area of management as well as to collect and provide access to performance and scalability data on the various management related challenges. Whereas UNIS and PSNC from a management framework perspective address scalability using a top down approach, UIB, UT, UIP and INRIA jointly follow a bottom up approach. Since results of the analysis of SNMP traces from WP2 will be used in WP7, also collaborations between INRIA and UT as well as between INRIA and IUB are integrated in the graph.

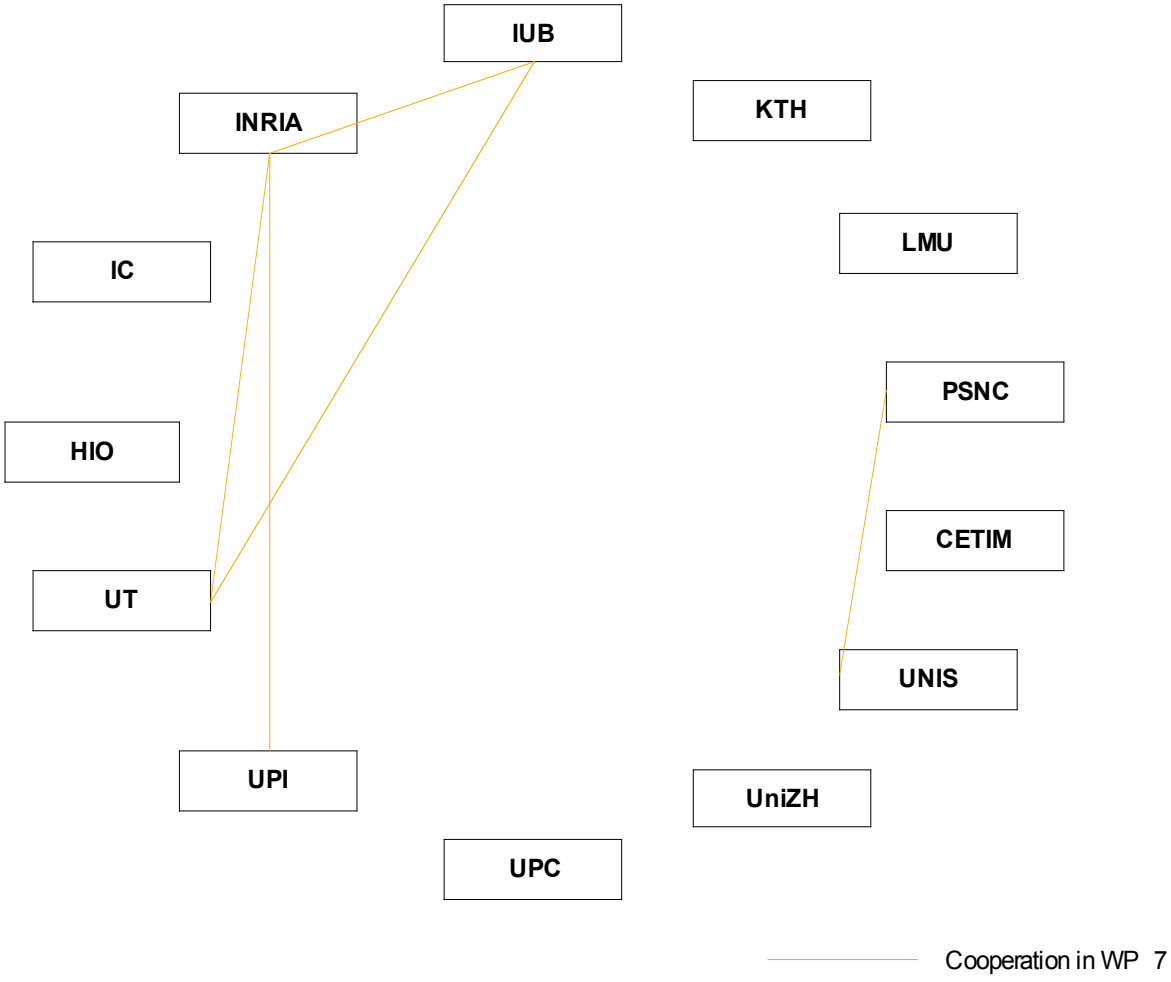

Figure 9: Collaboration in WP7

3.4.9 Collaborations in Work Package 8

The following graph presents the members of work package 8 (Economic Management of an IP Networking Infrastructure) and reflects current collaborations. Every single line integrated in Figure 10 indicates common research works as well as collective contributions of different EMANICS partners for the first deliverable. Examples of cooperative activities within WP8 are jointly composed sections as well as technical papers within similar research domains.

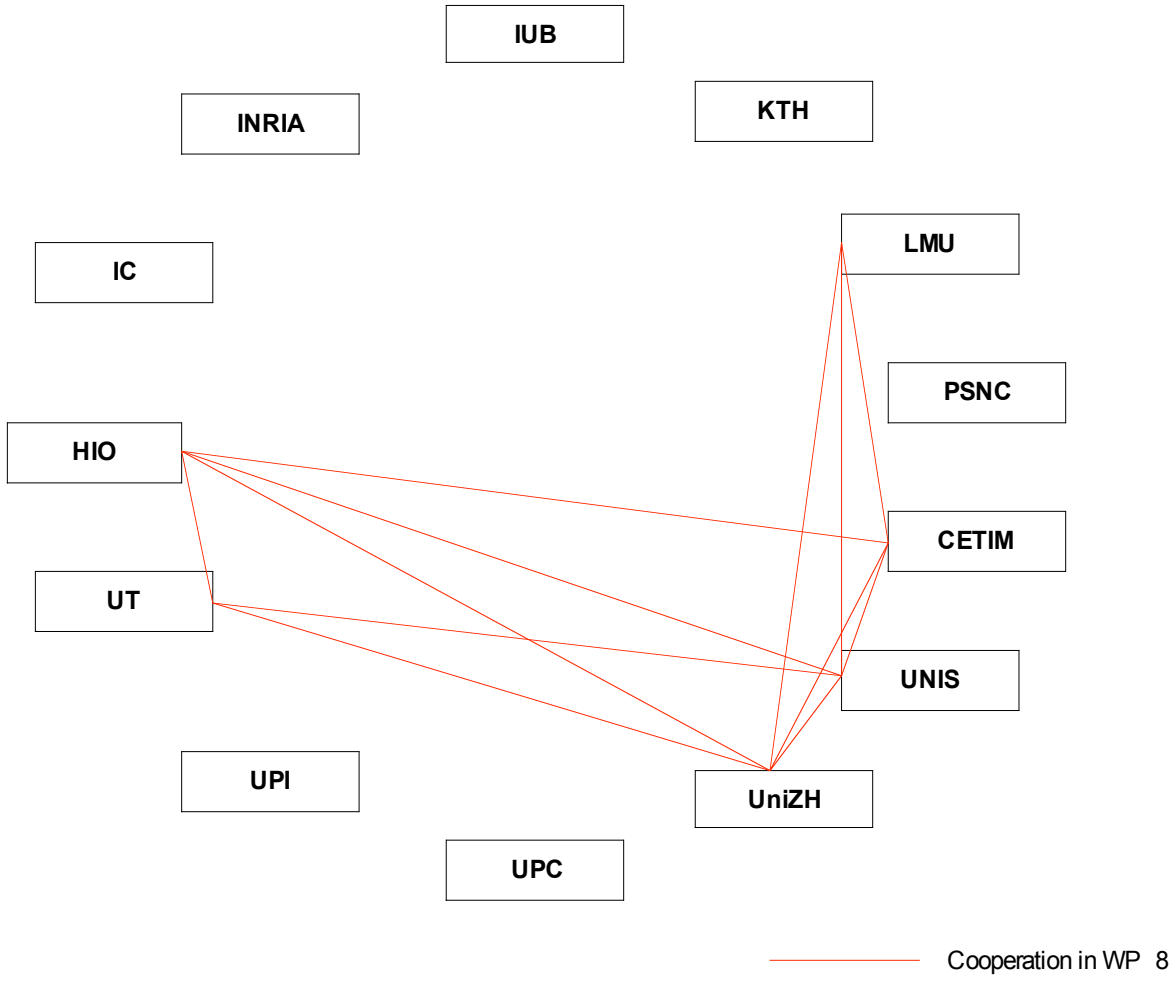

Figure 10: Collaboration in WP8

3.4.10 Collaborations in Work Package 9

Work package 9 (Autonomic Management), which is similar to WP8 also part of the research activities within the EMANICS project, has the purpose to address autonomic management issues of emerging next generation networks as for instance fixed NGN and cellular 3/4G networks as well as autonomic management issues in ad-hoc, ubiquitous and pervasive environments. Thus, a fundamental objective of WP9 is to produce an integrated, next generation management framework for autonomic management. Currently, 9 EMANICS partners have several collaborations and common fields of research participate in WP9.

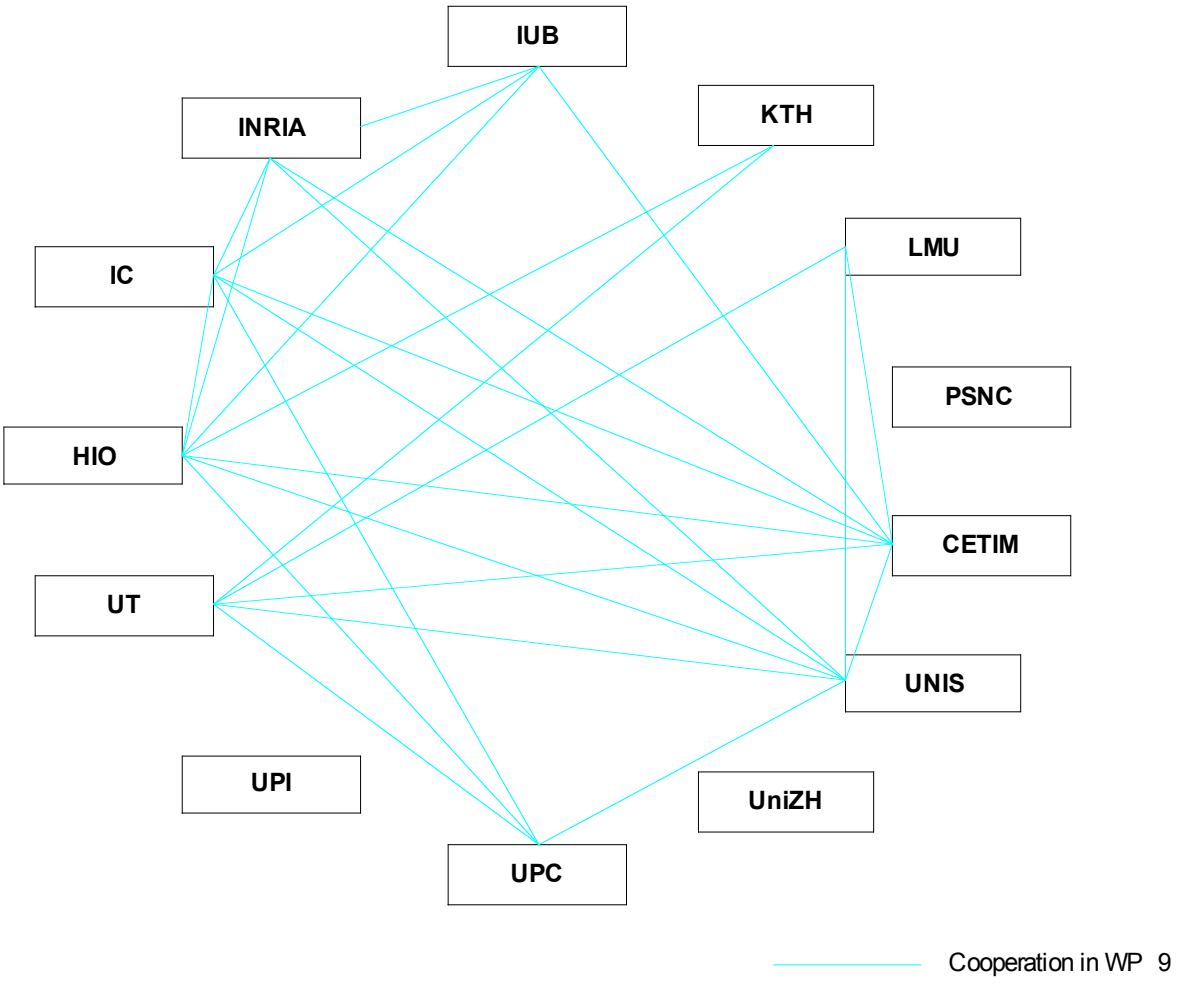

Figure 11: Collaboration in WP9

3.4.11 Overlay Map

Figure 12 presents a kind of an “overlay map” generated from the integration graphs of work packages WP2, WP7, WP8, and WP9 which reflects the entire number of connections between the partners of EMANICS with respect to the existing collaborations. Due to the fact, that in some work packages no distinct collaborations between institutions could be identified, these work packages have not been taken into account when creating the graph.

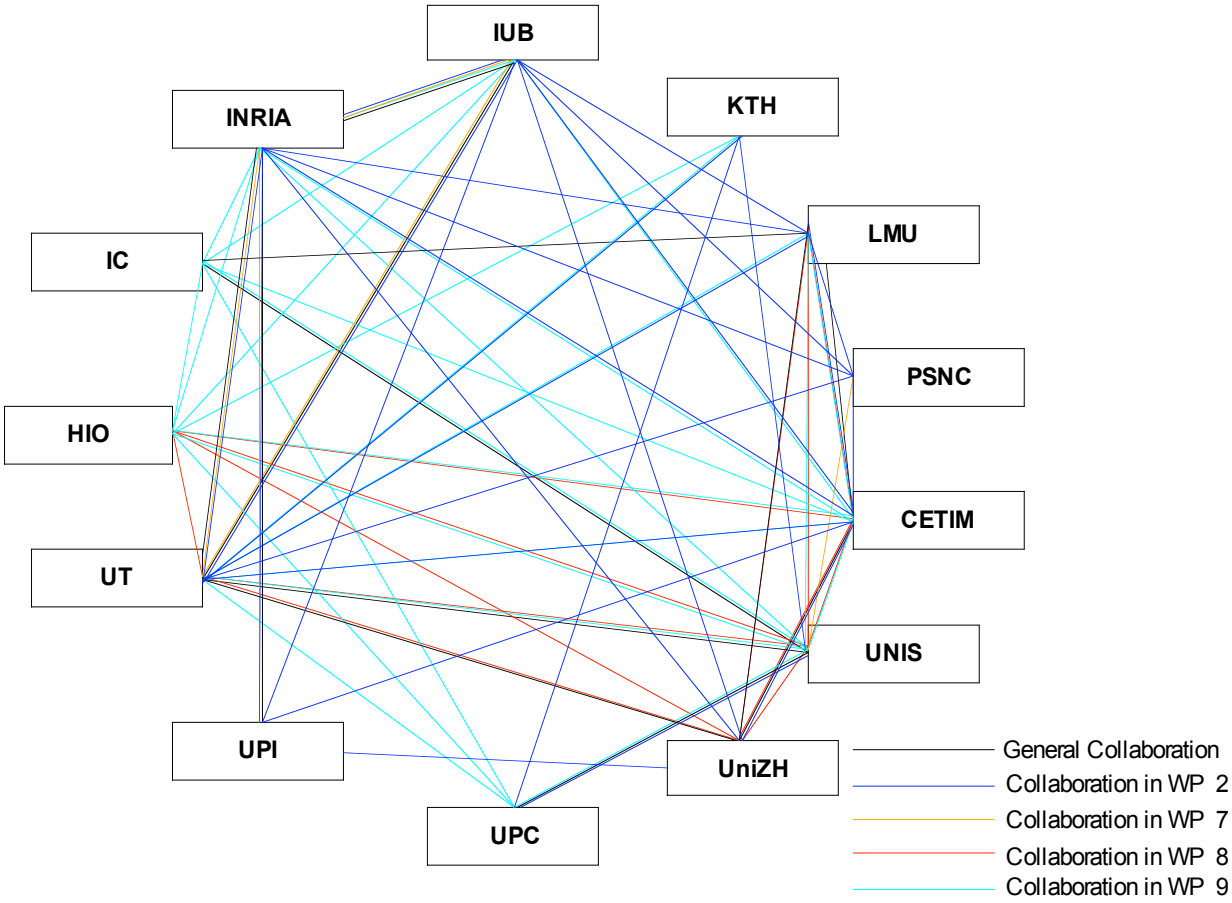

Figure 12: Overlay map composed of the integration graphs

Additionally, Table 1 contains a list of the number of connections for each work package in which an explicit collaboration between partners could be identified as well as a summation of all connections within the EMANICS project in order to quantify the currently existing degree of integration in the EMANICS network.

Please note, even the graph of WP2 (Figure 4) is more detailed, collaborations are only counted once in the above figure and the table below.

Institution	HIO	IC	INRIA	IUB	KTH	LMU	PSNC	CETIM	UNIS	UniZH	UPC	UPI	UT
# of general cooperation	0	2	3	2	0	3	0	2	3	3	1	1	4
# of connections in WP 2	0	0	7	7	3	5	5	7	2	4	2	4	6
# of connections in WP 7	0	0	3	2	0	0	1	0	1	0	0	1	2
# of connections in WP 8	4	0	0	0	0	3	0	4	4	5	0	0	3
# of connections in WP 9	7	6	5	4	2	3	0	7	7	0	4	0	5
$\sum$ of connections	11	8	18	15	5	14	6	20	17	12	7	6	20

Table 1: Degree of integration within the EMANICS network

3.5 Refinement and Extension of Quantitative Indicators for Integration

Several quantitative indicators for integration have been already proposed in the DOW under section 7.2.1 [5]. In the following section a more in-depth analysis of the identified quantitative indicators is performed, and also extended.

The main issue in developing such indicators, resp. metrics, is on the one hand the intention not to compare apples with oranges and on the other hand getting the metrics to complex and too extensive. *E.g.,* thoughts have been exchanged for example whether the amount of mails exchanged between partners documents a higher integration.

Another issue that needs to be emphasized more clearly is to distinguish between the

- visibility resp. importance of EMANICS to other communities (7.2.1.4) in terms for example of referenced papers, invited talks and presentation, and the
- integration within EMANICS.

Figure 13 visualizes this difference.

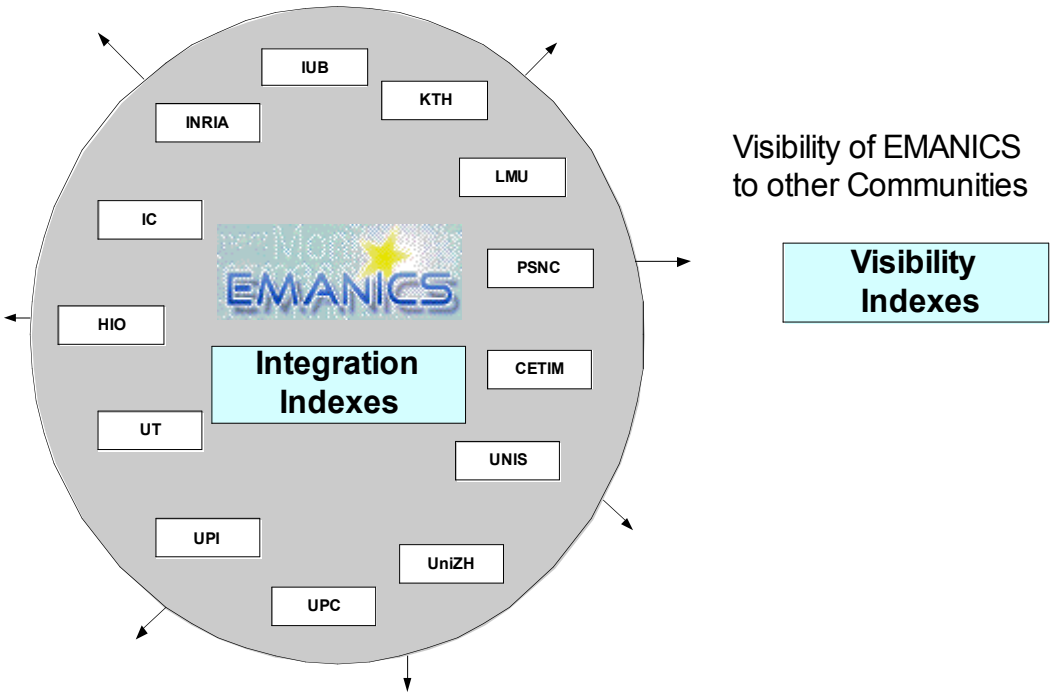

Figure 13: Integration vs. Visibility of EMANICS

Visibility refers to the point how often EMANICS papers are cited, whether EMANICS papers are accepted by journal, conferences or workshops etc. Thus, visibility refers to more qualitative indicators.

In the first six month of the EMANICS project only the integration within the EMANICS network has been considered.

3.5.1 Integration within EMANICS

This section shows the development of a quantitative metric called **Collaboration Index (CI)** representing the integration of partners within the NoE. The metric should be able to reflect the integration from three different views:

- How strong is the collaboration between two named partners of the NoE (*partner collaboration view*)
- How strong is a partner's integration in the NoE (*partner integration view*)
- How strong is the integration within the NoE itself (*NoE view*)

Basic data for the calculation of this index are bilateral activities. Activities comprising more than two partners are counted multiple times because they reflect a higher degree of integration. *E.g.*, an activity between 3 partners is counted as 3 bilateral collaborations, raising a partner's Collaboration Index twice as much as the same activity with only one other partner.

In order to quantify the degree of collaboration of the members within the NoE several "quantitative indicators", for instance joint published papers, as specified in section 7.2.1 in the DOW have been identified. Additionally, these quantitative indicators describe which activities can be seen as collaboration and serve as an essential means to measure the degree of the collaboration.

Based on [5] first initial quantitative indicators have been identified which will be further refined and extended during the project. Not all indicators mentioned in [5] in Section 7.2.1 are suitable to measure the degree of integration in the NoE, because some of them only reflect the visibility of the NoE, and will be taken into account when defining visibility indexes. Qualitative indicators described in [5], Section 7.2.2 as for example the quality of conferences and journals for published EMANICS results form the basis for the calculation of the visibility indexes.

An important criterion for the definition of the indicators and their respective measurable units was comparability. Where it was obvious, that two activities can not be compared with each other directly, a finer-grained unit was chosen. *E.g.*, simply counting visits may compare apples with oranges, if one visit lasts for a day, another one for a whole month. Where the identified unit is number we assume that the activities are roughly of the same size.

Table 2 shows the identified indicators with their measurable units.

Indicator	Unit	Description
Joint projects in EMANICS	Number	This indicator counts the number of subtasks of the work packages in which the partners participate
Joint published papers	Number	Papers which are composed by at least 2 partners and have been published

Visits	Days	Duration of a meeting of at least two EMANICS partners
Joint PhD Committees	Number	The number of inter-organizational supervision of Ph.D. or master thesis
Student exchanges	Days	The duration of students staying at the institution of a partner
Other tasks	Person days	Other common tasks within EMANICS which are not sub-tasks of WP7, WP8 and WP9, *e.g.*, Virtual Lab, joint software development or common activities with industry
General collaboration	Person days	Person-days spent in collaborations which already have been established before the EMANICS project started, *e.g.*, common industry projects, exchange programs

Table 2: Integration indicators

As a result, for each partner a collaboration tableau can be created as sketched in Table 3, and has to be filled out by each partner. The column with the own name has to be filled with zeros. As collaboration has no direction, each activity is rated twice. *E.g.,* CETIM rates the collaboration with the LMU and LMU rates the collaboration with CETIM. In the ideal case, those numbers should be same.

A table comprising integration activities for the first six months of the EMANICS project can be found on the EMANICS website under [6].

Furthermore, a prototype is under development to support the maintenance and update of quantitative and qualitative indicators in a distributed and convenient way. Lessons learned from using this prototype will lead to precise requirements to WP4 in order to implement such supporting tool in a productive way.

	INRIA	UT	IC	IUB	KTH	HIO	UPC	CETIM	PSCN	UniZH	LMU	UniS	UPI
Projects													
Papers													
Visits													
Committees													
Stud. Exch.													
Other tasks													
Gen. Coop.													

Table 3: Collaboration tableau

Appendix A defines three Collaboration Indexes to get a better description of the semantics of integration and the associated indicators:

The Bilateral Collaboration Index (BCI) meters the strength of collaboration between two named partners. The Collaborations Index of one partner ($CI_{Partnername}$) shows the integration of one partner within the network, and finally the Collaboration Index of EMANICS (CI_{NoE}) shows the overall integration in the NoE.

In further deliverables, WP1 will report on further improvements on the metrics, quantitative and qualitative.

3.6 Initial Teaching Map among EMANICS partners

In order to establish a common course program between all partners of the EMANICS network, an important task of WP1 is to identify current and future teaching activities as for example lectures, practical courses as well as seminars and colloquia of the EMANICS partners. Based on the results of the WP1 questionnaire [1] an initial teaching map has been developed, reflecting the focus of current and future teaching activities of the EMANICS partners. Since INRIA is not a teaching institute, the teaching activities of the members of INRIA in associated universities are depicted. Figure 15 graphically represents the focus of current teaching activities of the partners within the NoE.

As depicted in the lecture map in Figure 14, the teaching activities of the EMANICS members can currently be divided into 7 different fields of research. In general, several intersections between the teaching activities with respect to the offered lectures and courses can be identified, thus indicating related fields of research between the institutions. Additionally, it can also be observed that various correlations to the research topics which have been identified in Section 3.1 exist. Next deliverables of WP1 will include an identification of core courses as well as additional courses in order to establish a common course program on the graduate level which is consistent within all universities of the EMANICS network.

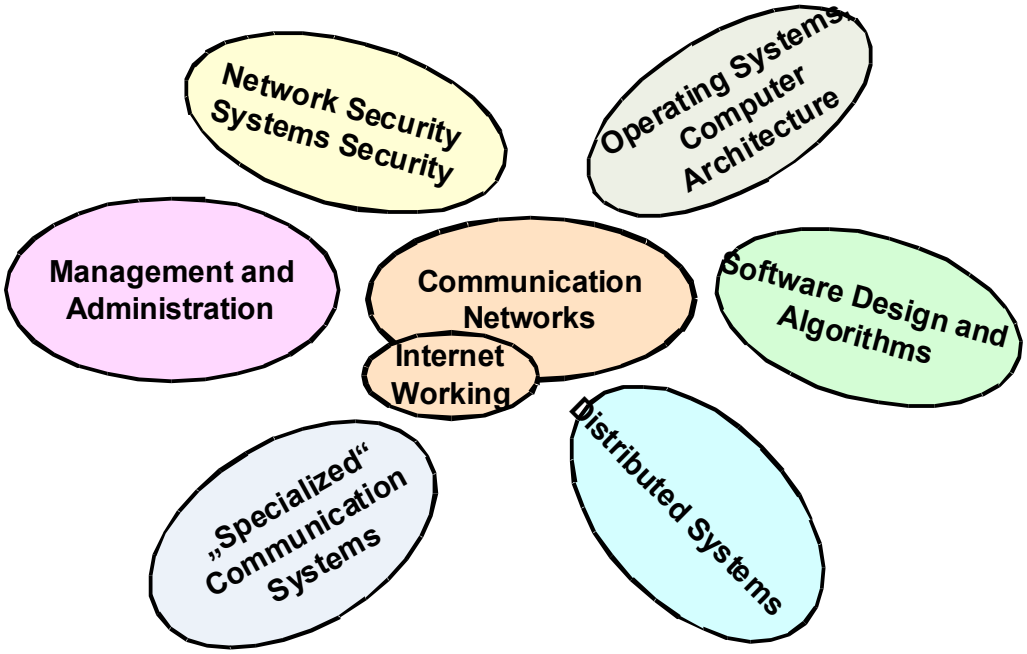

Figure 14: Lecture Map within the EMANICS network

Figure 15: Initial Teaching Map within EMANICS

4 New Challenges of IT Network and Service Management

Identifying new challenges of network, system and service management is a long-term process that identifies challenges from various perspectives and scenarios. In the following initial challenges are described that have been derived throughout the discussions with partners, experts, industry.

A more challenging issue is to develop a structured process to establish a common vision of promising future research topics. First steps in this direction have been already discussed among participants.

Reports from the National Science Foundation (NSF) and the Internet Architecture Board (IAB) about their view of challenges are presented as well.

4.1 Paradigm Shift to IT Service Management

Managing new services on many different types of networks with many different players are among the challenges. Along with them is the need for seamless interoperability and interdependence between services and networks. In this area, service providers compete for customers with high quality services, with the ability to deploy services rapidly and efficiently, to make the ordering of services extremely simple and keep inconvenience for the customer at a minimum as well as the ability to rapidly introduce and roll out new service offerings. Furthermore, it means to deal with issues such as service quality, adaptable infrastructures, federated services, fast deployment and introduction of innovative services, customer-orientation, supply chains just to name a few.

Instead of resources such as network devices, end systems and applications, it is necessary to think in terms of services that depend on other services, and are realized in a distributed manner on several resources (i.e., distributed service provisioning). Figure 16 sketches the new environment to deal with.

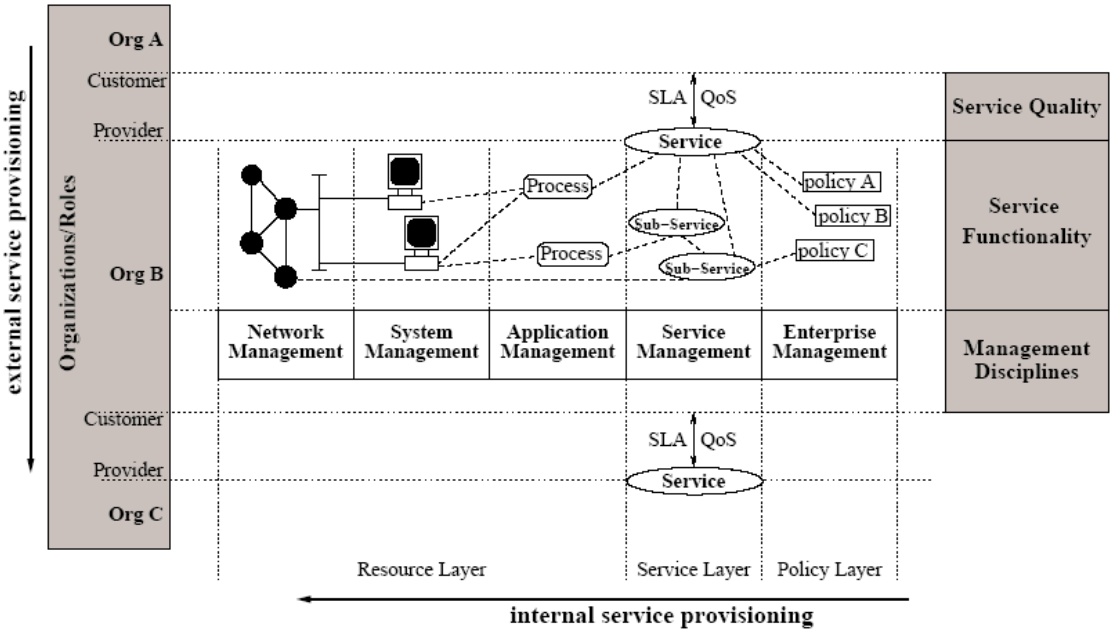

Figure 16: General model of IT service management

The comparison of device-oriented versus IT service management, as summarized in Figure 16, gives a preliminary understanding of some of these new challenges:

1. **Service as Managed Object.**

   Managed objects of device-oriented management are individual resources (*e.g.,* network devices, end systems or applications); managed objects of IT service management are distributed IT services such as Web, Email or E-commerce services which are provided in a distributed manner by several resources.

2. **Management of the Infrastructure wrt. Service Level Agreements (SLAs).**

   Management issues of device-oriented management are related to the management of independent resources and refer for example to questions whether a device is reachable, what is the CPU load of a server and what processes are running on a specific end system. Management questions of IT service management address issues of managing resources with respect to the delivered services and agreed service level agreements (SLAs). The challenge of IT service management is the necessity to cope with dependencies between services and the distributed provision of services upon several resources.

3. **Management Driven by Customer Requests.**

   Device-oriented management is driven almost exclusively by the provider's objectives. IT service management is driven by customer demands and his requirements with respect to services and service quality. After all, this is what service providers are all about.

4. **Providing Quality of Service, Service Level Management.**

   Quality in device-oriented management was a relevant issue only for a provider with respect to the utilization of resources. It was almost limited to the observation of

	Device–oriented management		IT service management
1.	Resources	→	Distributed services
2.	Management of independent resources	→	Management of dependent services and resources
	Functionality on individual resources	→	Distributed provision of a service upon several resources
3.	Provider role	→	Customer and provider role
4.	Quality of Device Parameters	→	Quality of Service Parameters Service Level Agreements Operation Level Agreements
5.		→	Federated services
6.		→	Customer Service Management

Figure 16: Device-oriented vs. service-oriented management

Management Information Base (MIB) variables (*e.g.,* IfInPackets, CPU load, storage utilization, software version) of a particular device or component. We refer to MIB variables of devices as Quality of Device (QoD) parameters. Quality of Service (QoS) is in opposite one of the most important issues that a provider needs to address within IT service management. Qualities of the provided services are agreed between a customer and a service provider in Service Level Agreements (SLAs) and specified with QoS parameters such as throughput, delay, blocking probability, availability, Mean-Time-To-Repair (MTTR) and Mean-Time-Between-Failure (MTBF). They need to be defined in a customer-centric and service-oriented way although the opposite is the common practice among providers. QoS parameters are calculated based upon available QoD parameters.

5. **SLA/OLA Chains.**

   If services are provided by several providers (i.e., so-called sub-providers), QoS agreements between a provider and a sub-provider are also handled with SLAs, respectively Operation Level Agreements (OLAs). SLA/OLA management in such federated environments is of special importance.

6. **Providing Information to Customers in an Adequate Way (CSM).**

   A new challenge is also the necessity to provide a Customer Service Management (CSM). This results primarily due to the fact that customers want to be informed about the quality of the subscribed services for which they are billed. They require one interface to the provider's management to access reports about the provided quality of the subscribed services, to report problems with services, to order services etc. Concepts to address these issues are summarized under the term CSM.

7. **Organizational IT Service Management (ITIL, eTOM).**

   Another challenge is certainly devoted to organizational IT service management that is represented by the two IT business process frameworks ITIL (IT Infrastructure Library, [7]) and eTOM (enhanced Telecom Operations Map, [8]), as well as SOA (Service Oriented Architectures, [9]), a new paradigm for building service infrastructures. ITIL and eTOM present relatively mature frameworks - TOM, the predecessor of eTOM, was first published in 1998, the earliest ITIL publications date back to the late 1980's. SOA by contrast is a currently still evolving idea that has yet to result in significant standardizations.

4.2 Grid Computing

Grid computing and the implications to management can be considered as one of the great challenges of management. The importance of this topic and the associated management challenges is reflected in various projects such as D-Grid [10]. Within Grid environments several new challenges of management are identified as a consequence of the virtualization of resources, services and even organizations (i.e., Virtual organization, VOs).

Within the German D-Grid which has the objective to establish a sustainable Grid infrastructure in Germany, several so-called Community-Grids (*e.g.*, MediGrid, AstroGrid, HEP-Grid, etc.) and resource providers (*e.g.,* supercomputing centers, universities, etc.) jointly offer a broad range of complex Grid resources and Grid services to the German scientific community. Fundamental research activities of the so-called D-Grid integration project (DGI) cover for instance the inter-organizational monitoring, accounting and billing of resources and services within multi-provider scenarios, and thus address new as-

pects of IT service management across organizational boundaries. Additionally, other essential research tasks within D-Grid deal with issues of networking and security as well as the deployment and operation of Grid infrastructure and middleware services.

4.3 Biometrics

Scalable IT management is becoming more and more important due to growing management data and more complex systems. A hierarchical management approach, which scales well, is one possible choice. However, hierarchies do not offer much flexibility as such.

Thus, in the BioLANCC project [25], a biometric data management system is being developed to tackle this problem for biometric management data required to allow access of people to physical resources such as rooms or doors, electronic resources such as programs or logins, or any type of IT resource in general. The goal of BioLANCC is to offer a model for scalable IT management systems in the area of biometric data management, which will offer scalability in terms of numbers of users and control devices as well as flexibility in terms of assigning those in various levels of combination at the same time.

The key focus of this project is to provide a modeling framework that builds a distribution graph of person-resource attribute pairs in the most flexible and user-friendly manner. According to this distribution graph, management functions for biometric data, such as fingerprints or face scans, are distributed securely to specific, remote biometric devices, which enable BioLANCC to operate most efficiently in a fully distributed access scheme of its resources.

4.4 Autonomic Management

The propagation of Internet technologies, services and resources, has made the current network systems and services difficult to manage and insecure. The underlying approach to deal with the complexity, heterogeneity and uncertainty of current networks is based on autonomic computing having the capabilities of being self-defining, self-healing, self-optimizing and self-managing.

New challenging research activities in the domain of autonomic management address various issues of automated management in the context of both fixed Next Generation Networks (e.g. QoS-enabled IP Networks) as well as ad-hoc/ubiquitous environments. Thus, key objectives address the development of frameworks for autonomic management for both types of networks focusing on the required functionality as well as underlying management technologies used in order to support the requirements of autonomic management of fixed and ad-hoc networks.

Important aspects in the context of the management of fixed QoS-enabled IP Networks that have to be addressed are for example enhancing the network performance while optimizing the use of network resources.

Furthermore, essential issues as for example resilience and fault tolerance also have to be incorporated.

Autonomic management of ad-hoc/ubiquitous environments concentrates on mechanisms and components to support autonomic management of ad-hoc networks regarding aspects as for instance the self-organization, self-protection as well as self-adaptation of ad-hoc/ubiquitous environments.

4.5 Report of the NSF Workshop on Fundamental Research in Networking

In 2003, the National Science Foundation (NSF) [11] organized a two-day workshop dedicated to the establishment of the agenda of future research in networking. This workshop brought together many leading US-located scientists in the area of networking. The report [12] that came out of this workshop is very often cited as a guide in the networking community.

Unsurprisingly, the outcome of this workshop is also a very interesting input to the network and service management community. Two reasons for this: first management (manageability) is clearly cited as part of the challenge identified in the report, second research in management as a discipline has evolved almost in the same lane as research in networking and general findings and recommendations for the later are also of high relevance to the former.

The goal of this section is to provide an initial input towards a roadmap for future research on network and service management, the recommendations that emerged from the NSF workshop and to instantiate them in the management discipline.

This identification of enhanced need for manageability and management as identified by the networking community is also visible through the increasing number of events/papers in the networking community which are dedicated to network management (*e.g.*, INM'06 in the context of SIGCOMM [13], [14]).

Almost all general recommendations that emerge from this workshop do also fully apply to the research on networking management.

The first two recommendations are very relevant to management. The first one encourages **fundamental and breakthrough research that seeks innovation and paradigm shift**. Coupled with the second recommendation **to foster multidisciplinary aspects of fundamental research in networking**, they lead to innovative projects like the Clean Slate networking programs that are growing in the US [17][18].

In the context of network and service management, these recommendations lead to encourage research that rethinks from the scratch, the management paradigms, models and techniques. Within EMANICS, this vision is addressed to some extend in work package 9. The multi-disciplinary aspect, while explored by some academics in the discipline through increase collaboration with other communities (social science, economics, …) remains a big challenge in network and service management.

Another recommendation emerging form this report that is of major importance to management is **the need to fully support reproducibility of experiments and benchmarking**. It is only very recently that the management community has started to seriously think of those two issues which are as mentioned in the NSF report "hallmarks of scientific and engineering pursuits". EMANICS is contributing a lot to both the collection and sharing of data and to the establishment of clear benchmarking metrics and frameworks. Efforts however need to be increased in this direction in various directions (simulation, emulation, benchmark networks, management behavioural models, …) for the benefit of the community.

In networking like in their management applications play a major role. Also the NSF report encourages "**closer tier between application research and networking research"** to better identify the requirements on future networks through visionary applications**.** This recommendation has two impacts on the management research. First, it

clearly encourages to think of management in terms of its usability and applicability to future applications. This means, as already identified in the report, investigating the management planes according to new metrics like: manageability, invisibility, cost, ease of use/configuration, scale, heterogeneity, … The notion of manageability appears also in other initiatives and reports under the term: designed for manageability. Within EMANICS some of the metrics are considered: scale and cost in WP7, ease of use/configuration and manageability in WP9. They represent a good starting point in this direction. The second impact of this recommendation can also be mapped in the management plane as an incentive to increase efforts towards the merge between systems/application and network management which did over the last few years diverge on many aspects. This is not addressed so far by the community.

Finally, even if not provided in the report as a recommendation, the NSF workshop has worked on a set of case studies and has identified as set of new networking types which are highly relevant to the new challenges. All these new networking approaches (overlay networks, virtual networks, sensor networks, …) are undoubtly of very high interest to the management community since in addition to networking challenges, they bring very interesting management challenges that need to be addressed to enable their wide acceptance and deployment as part of the future Internet.

4.6 IAB Network Management Workshop

In June 2002, the Internet Architecture Board (IAB) [15] organized a workshop to guide the IETF's focus on future work regarding network management. The workshop was attended by network operators and protocol developers. The workshop report has been published as RFC 3535 [19].

The protocol developers analyzed the current state of the art of Internet management protocols and this was contrasted later with the requirements formulated by the operators. During the workshop, it became very clear that the biggest obstacle is configuration management. Furthermore, monitoring is not always as accurate as it should be. A total number of 33 detailed observations were formulated which were further condensed into the following eight recommendations:

1. The IETF should stop to force working groups to provide writable SNMP MIB modules.
2. A group should be formed to investigate why current SNMP MIB modules do not contain all the objects needed by operators to monitor their networks.
3. A group should be formed to investigate why the current SNMP protocol does not satisfy all the monitoring requirements of operators.
4. The IETF focus resources on the standardization of configuration management mechanisms.
5. The IETF/IRTF should spend resources on the development and standardization of XML-based device configuration and management technologies (such as common XML configuration schemas, exchange protocols and so on).
6. The IETF/IRTF should not spend resources on developing HTML-based or HTTP-based methods for configuration management.

7. The IETF should continue to spend resources on the evolution of the SMI/SPPI data definition languages as being done in the SMIng working group.
8. The IETF should spend resources on fixing the MIB development and standardization process.

The IETF reacted to these recommendations by forming the Network Configuration Working Group (NETCONF) [16] working group in 2003 which has since then been working on an XML-based network configuration protocol. The basic protocol specifications have been completed and are expected to be published in 2006. Note that data modeling for NETCONF has not been defined yet.

It should also be noted that NETCONF only aims at providing an interoperable configuration interface. The construction of flexible, portable and robust configuration management systems remains to be solved by the industry or the research community.

4.7 IAB Concerns and Recommendations Regarding Internet Research and Evolution

In 2004, the Internet Architecture Board (IAB) produced a document which points out that ongoing research is needed to further the evolution of the Internet infrastructure [20]. Section 3.5 discusses network management. However, as stated in the beginning of section 3, the set of topics discussed is not intended to be comprehensive, but instead is intended to demonstrate the breadth of open Internet research questions.

1. The first research question concerns the management perspective. Most existing tools are good for managing isolated devices but not for managing large networks as a single large distributed system.
2. The second research question concerns enhanced monitoring capabilities. Research is needed on scalable distributed data aggregation mechanisms, scalable distributed event correlation mechanisms, and distributed and dependable control mechanisms. This specifically includes scalable techniques for data aggregation and event correlation of network status data originating from numerous locations in the network.
3. A third research question concerns end-user interfaces or customer oriented network management. In particular, research is needed to build systems that help users and others to identify and resolve problems in the network.
4. A fourth research question concerns the level of automation achieved in network management. In particular, research on more autonomous and decentralized / localized management should be undertaken which might include the application of control theory or artificial intelligence techniques to network management problems.

The four topics listed above indicate that on the one hand some topics which have already been investigated for quite some time remain relevant (*e.g.,* scalable monitoring) and on the other hand new topics need to be investigated (*e.g.,* decentralized user-oriented troubleshooting or the development of autonomic networks). In addition, it seems crucial to focus more on networks as a large distributed system and to overcome too device oriented views.

4.8 Approaches to Acquire and Update Information about Challenges

New challenges and visions can in most cases be determined only by discussion among researches. Thus, workshops and conferences allow a good basis for doing so.

4.8.1 Workshops, Meetings, and Conferences with Researchers

WP1 will issue a request to the

- DSOM'06 [26] Co-Chairs to organize an EMANICS panel on the identification of new challenging issues of network and service management;
- Panel co-chairs of IM'07 [23] to organize a panel on the vision and new challenges of IT management;
- General chair of AIMS [24] in order to organize a panel on this as well.

4.8.2 Workshops and Meetings with Industry, Service Providers, Consulting Companies

Industry and service providers have their own views about potential new research topics. The same holds also for consulting companies. Valuable results have been achieved also at the **Theta days** that are reported by WP 3. Other similar events can follow either in a more local manner or in a wider context. A workshop between industry, large service provider and consulting companies is planned for example in November in Munich to attract local people.

To identify topics for future network and systems management research, a two day joint IRTF-NMRG / EMANICS workshop will be organized. This workshop will provide valuable input for researchers who define new Ph.D. or larger size research projects, and people who coordinate research and standardization in the area of network and systems management. The workshop might also provide input for future EU research programs.

To be able to invite some key people, the idea is to organize this workshop just before the start of ManWeek, on October 19 and 20 2006 [27]. The workshop should be organized close to one of the main airports, for example in Utrecht (the Netherlands), Zurich (Switzerland) or Heidelberg (Germany). To keep organization simple and discussions lively, the workshop will be limited to 25 or 30 attendees. Workshop attendance will be based on invitations only. Next to EMANICS and the Internet Research Task Force - Network Management Research Group (IRTF-NMRG) [28], people will be invited from organizations like the IAB, IETF, network operators, server hosting companies, manufacturers, companies with major IT infrastructures and leading researchers from outside EMANICS (for example IFIP and CNOM).

5 Ph.D. Integration Program

With its students, especially its Ph.D. students, the network has the opportunity to establish a European integration program which outlives the lifetime of EMANICS. In a first step the partners are founding joint Ph.D. committees to establish more inter-European contacts for Ph.D. students and international support.

The following joint Ph.D. committees have been established so far:

Supervisors: Prof. Stiller, University of Zurich

Prof. Dreo, University of Federal Armed Forces

Theme: Frank Eyermann: *Auditing of Internet Services*

6 Conclusions

First fundamental activities within WP1 embraced the identification of current fields of research of the members within the EMANICS network as well as the establishment of an integration graph in order to evaluate the current degree of integration achieved within the NoE.

The structured representation of research activities serves as an essential means in order to assign experts to and within each field of research. Furthermore, the research map can also be used as a valuable basis to establish smaller research teams within the network which work on similar topics. Although at the moment only to some extend intersections within the fields of research can be identified, several key aspects evolve in the research domains of the EMANICS members.

Beside the identification of major research activities, another important issue of work package 1 is the construction of a map, which adequately reflects the degrees of integration as well as the involvement of single institutions within the Network of Excellence. However, the graphs only represent a course illustration of the current stage within the EMANICS project. An important task in the future will be to annotate the links between cooperating partners within the work packages in order to specify the tasks of collaboration more precisely. Additionally, since the integration graphs are only useful when updated on a regular basis, the map should at least be updated quarterly. Another interesting aspect will be to represent the collaborations and activities within each work package in a table form reflecting the collaboration between partners as well as the performed activities in a structured way.

Furthermore, an essential task of WP1 will be the development of an adequate tool in order to generate and maintain the integration graphs automatically. Therefore, one of the main goals in the future will be the establishment of an repository as for instance a kind of Wiki, in which a list of the EMANICS participants containing the names of experts, research activities, current and future projects as well as collaborations with other universities and the industry will be included. Additionally, the activities between partners within the different work packages could be specified in a greater detail and also be stored in the repository.

Another important aspect of WP1 is the identification of new challenges of IT Management between the EMANICS partners. Due to different expertise of the participants of the NoE as well as diverse fields of research, various promising challenges in the domain of IT management could be identified. In the future, the description of new research topics should become an appropriate reference for researchers which can be used, *e.g.*, to write project proposals as well as to serve as a basis for the definition of future EU research programs.

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8 Abbreviations

AAA	Authentication, Authorization, Accounting
CSM	Customer Service Management
eTOM	Enhanced Telecom Operations Map
IAB	Internet Architecture Board
IETF	Internet Engineering Task Force
IP	Internet Protocol
IRTF	Internet Research Task Force
ITIL	IT Infrastructure Library
JEMS	Journal and Event Management System
MIB	Management Information Base
MTBF	Mean-Time-Between-Failure
MTTR	Mean-Time-to-Repair
NGN	Next Generation Network
NoE	Network of Excellence
OLA	Operation Level Agreements
QoD	Quality of Device
QoS	Quality of Service
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SOA	Service Oriented Architecture
VO	Virtual Organization
VoIP	Voice over IP

9 Acknowledgements

This deliverable was made possible due to the large and open help of the WP1 team of the EMANICS team within the NoE. Many thanks to all of them.

Appendix A Calculation of the Collaboration Indexes

The first step in order to define the calculation is the definition of a common weighting vector $\vec{w} = \left(w_{projects}, w_{papers}, w_{visits}, w_{committees}, w_{stud.exch.}, w_{other}, w_{gen.coop.}\right)$, which allows to compare the different kinds of activities and calculate the Bilateral Collaboration Index (BCI) for each partner.

Taking the content of Table 3 (see Section 3.5.1) as a matrix $C_{Partnername}$ (*Partnername* denoting the name of the EMANICS partner filling the table) the BCI can be calculated as

$$BCI_{Partnername} \equiv \vec{w} \times C_{Partnername}$$

The BCI is a vector, showing how strong the collaboration of one partner with all others is and therefore the BCI directly represents the collaboration view. The BCI can be printed as a further line of Table 3, which weighted sums up the values in the column above.

The partner's Collaboration Index (CI) can be calculated as the norm of $BCI_{Partnername}$

$$CI_{Partnername} \equiv \left|BCI_{Partnername}\right|$$

and is the degree of the partner involved in the NoE (partner integration view). It is a simple scalar value.

Finally, adding up all $CI_{Partnername}$

$$CI_{NoE} \equiv \sum_{partnername} CI_{partnername}$$

results in the Collaboration Index of the EMANICS project.

$BCI_{Partnername}$, $CI_{Partnername}$ and CI_{NOE} provide a snapshot view of the integration and collaboration in one period; i.e. one fills Table 3 with all activities of the last period. The length of the period has to be defined; proposed is a value of three to six month.

As integration is a process with memory, a period's snapshot can not adequately represent the integration over time. Activities in past periods have to be taken in to account, too. The calculation for Collaboration Indexes for subsequent periods is defined as a weighted moving average, with weighting factor *a* ($0 \le a \le 1$). The factor *a* defines how fast past events should be forgotten: the greater *a* is (i.e. closer to 1) the faster the relevance of the past decreases. A value of 0.3 is proposed which means that the influence of past events is below 1% after four periods:

- For the very first period (denotes by a superscript 0):
  $$BCI_{Partnername}{}^{0} \equiv \vec{w} \times C_{Partnername}$$
- For period i, directly following period i-1:
  $$BCI_{Partnername}{}^{i} \equiv a\left(\vec{w} \times C_{Partnername}\right) + (1-a) BCI_{Partnername}{}^{i-1}$$
- The definition of $CI_{Partnername}$ and CI_{NOE} remains the same, as the memory was already implemented in $BCI_{Partnername}{}^{i}$
  $$CI_{Partnername}{}^{i} \equiv \left|BCI_{Partnername}{}^{i}\right|$$
  $$CI_{NoE}{}^{i} \equiv \sum_{partnername} CI_{partnername}{}^{i}$$